



Satellite data used in the New European Wind Atlas

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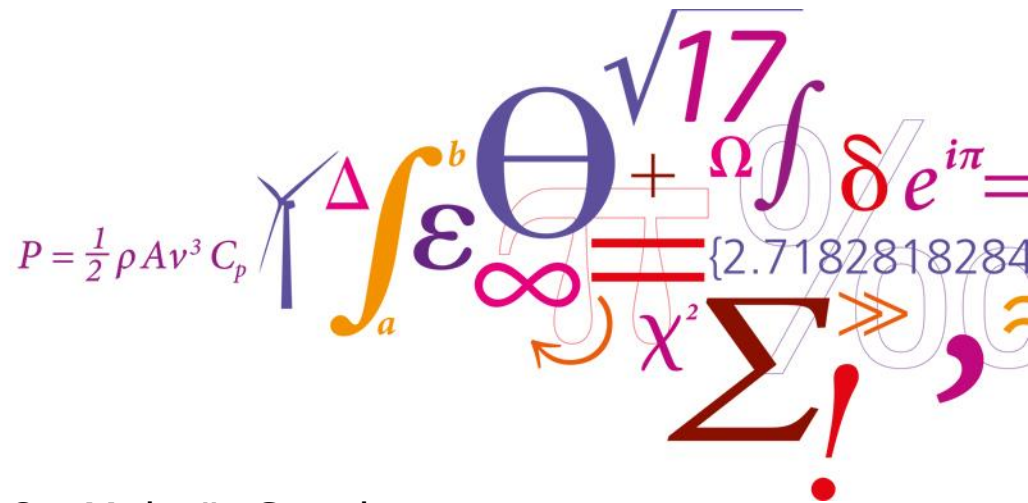
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Satellite data used in the New European Wind Atlas

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VindkraftNet 29 November 2016, E.On Malmö, Sweden

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- ✓ Satellite data
 - Objectives
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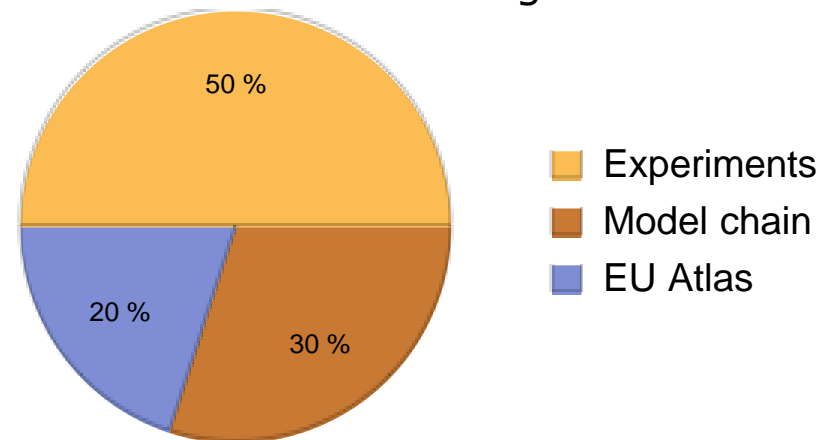
Purpose and structure of NEWA

- Accurate mapping of wind conditions for the estimations of resources and loads
- Development and testing of the model chain
- A series of atmospheric field experiment to validate the model and atlas.

9 national funding agencies from
8 countries
30 partners

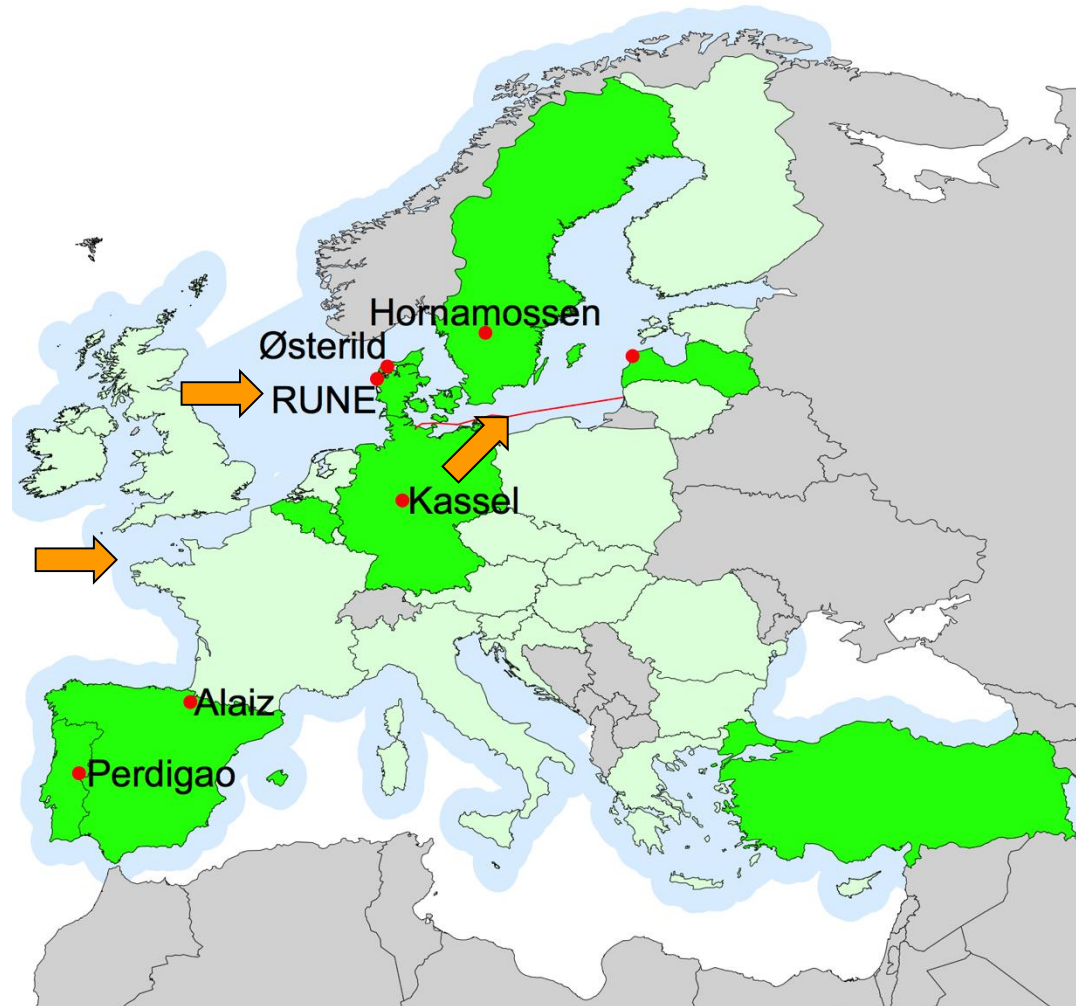
<http://www.neweuropeanwindatlas.eu/>

NEWA budget

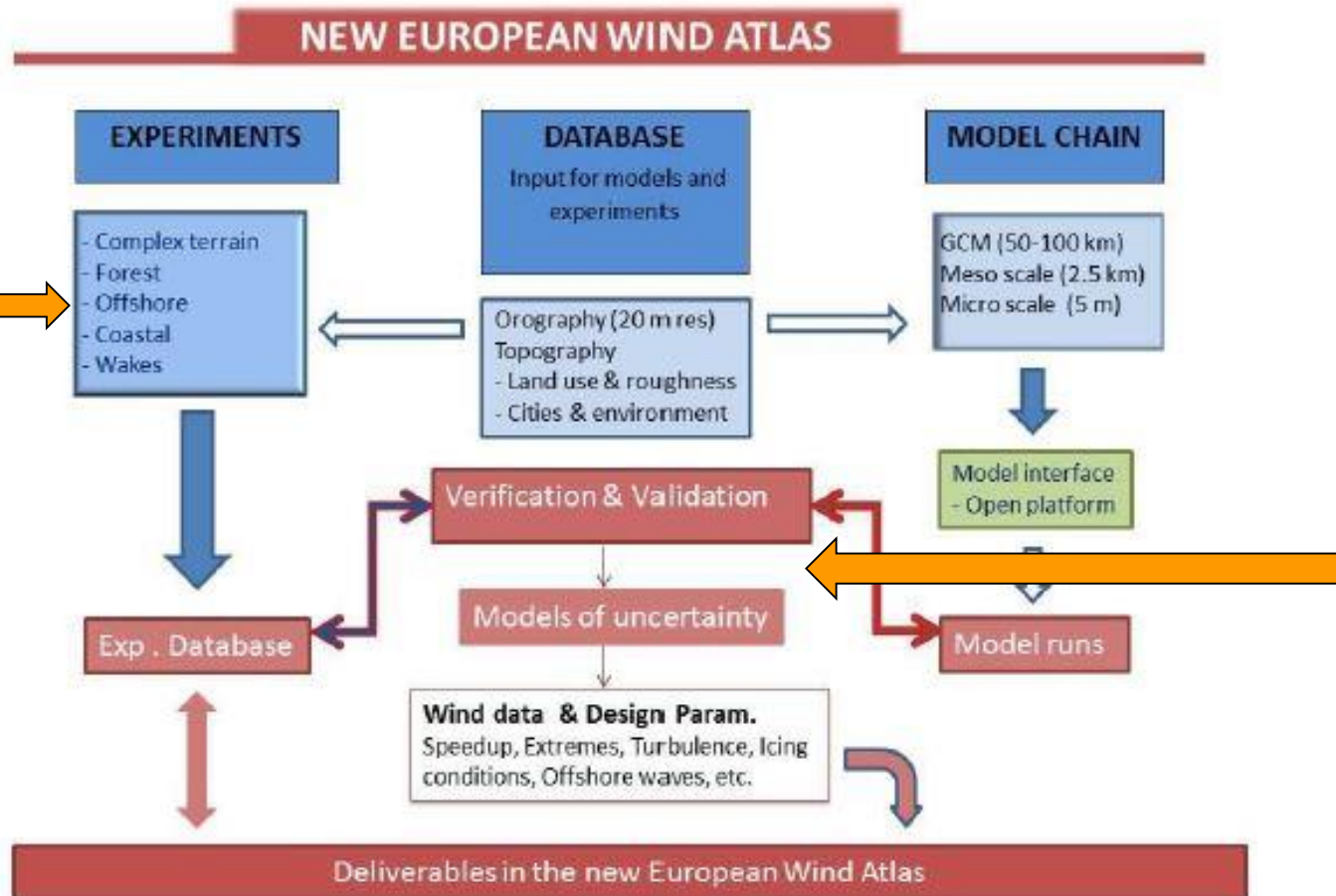


Experiments in the New European Wind Atlas

- EU countries
- **NEWA partners**
- Offshore coverage
- **Experimental sites**



New European Wind Atlas



Satellite data

Satellite data:

Objectives for NEWA offshore wind atlas

- ENVISAT ASAR data archive to cover all of Europe
- Sentinel-1 data to cover all of Europe
- Validate Sentinel-1 wind fields
- Merge ENVISAT ASAR and Sentinel-1 to a complete SAR wind atlas
- Possibly integrate with NEWA's modeling chain:
 - higher-resolution model wind directions as input
 - lifting of satellite winds beyond 10 m
- Use ASCAT wind statistics for comparison to models
- Use SSM/I wind statistics for comparison to models
- Compare satellite data to ship lidar data
- Sea surface temperature input to models

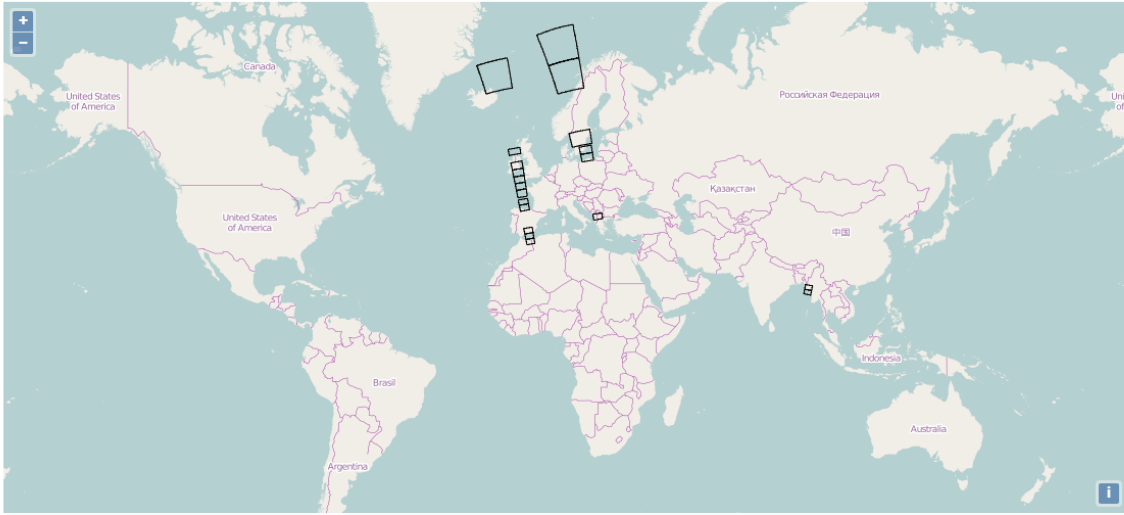
SAR wind data archive at DTU

- 30,000+ ENVISAT ASAR scenes (2002-2011)
- 36,000+ Sentinel-1 A/B SAR scenes (2014->)

DATA STATION

Home Satellite winds

[Log In]



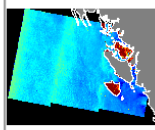
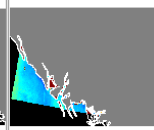
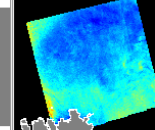
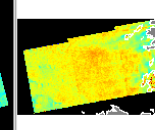


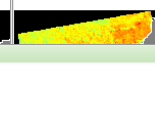
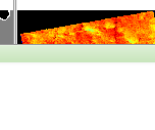
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SATELLITE WIND FIELDS FILTER

Filtering options

Date range - from to

Latitudes from to

Longitudes from to

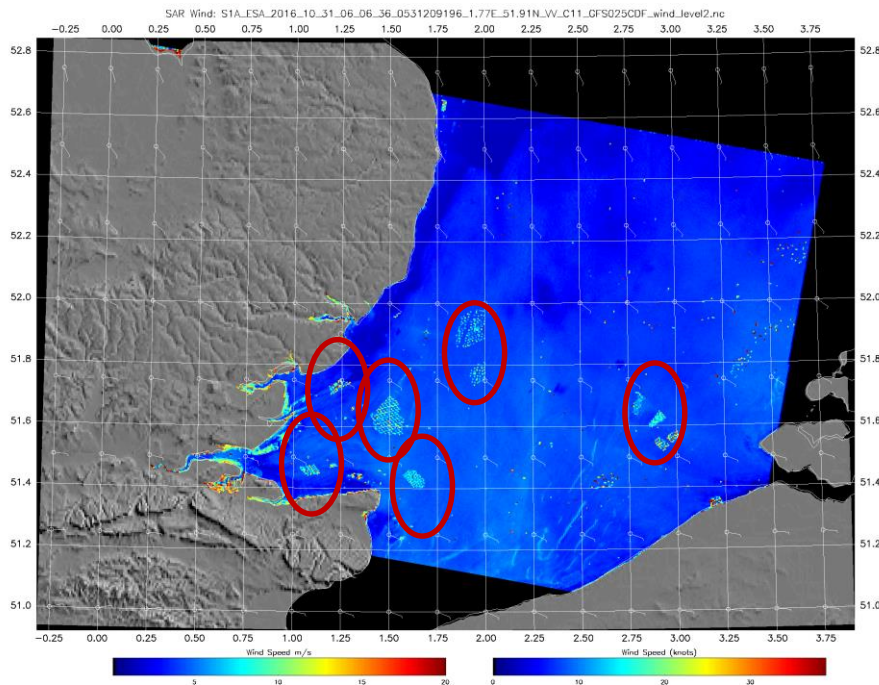
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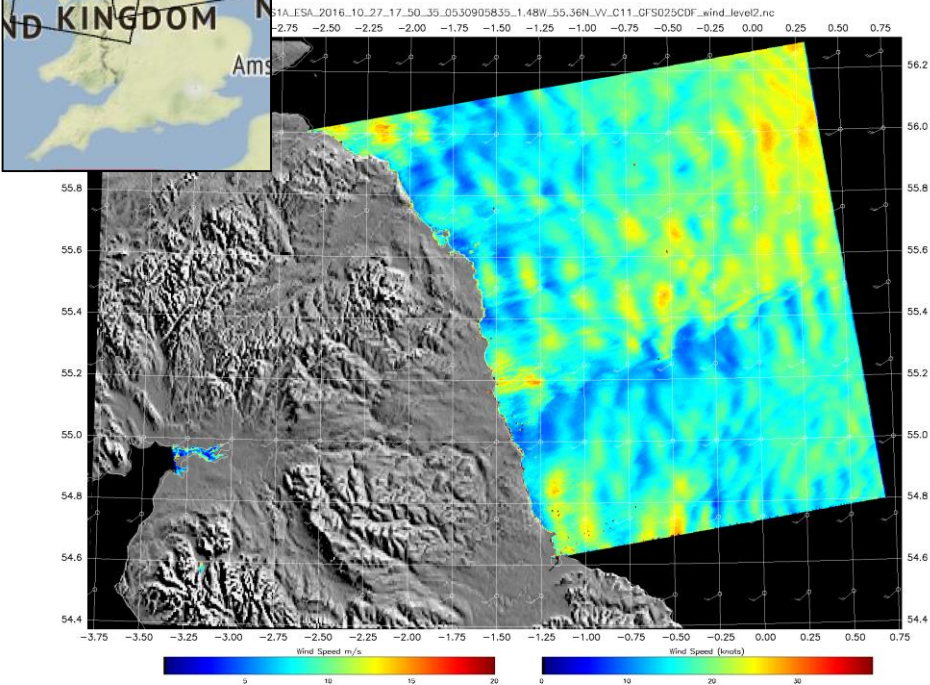
SAR Ocean Products System (SAROPS)

- Evolved from the APL/NOAA SAR Wind Retrieval System
<http://fermi.jhuapl.edu/>
- SAR wind retrieval in near-real-time
- DTU covers the European seas (routine)
- Merete Badger operates SAROPS at DTU

Sentinel-1 over the UK



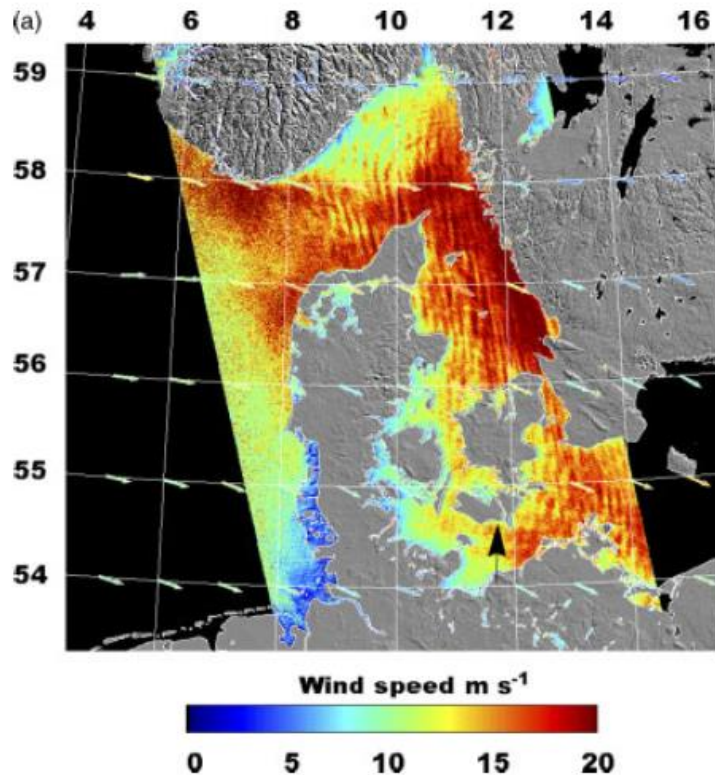
October 31, 2016 at 06:06 UTC



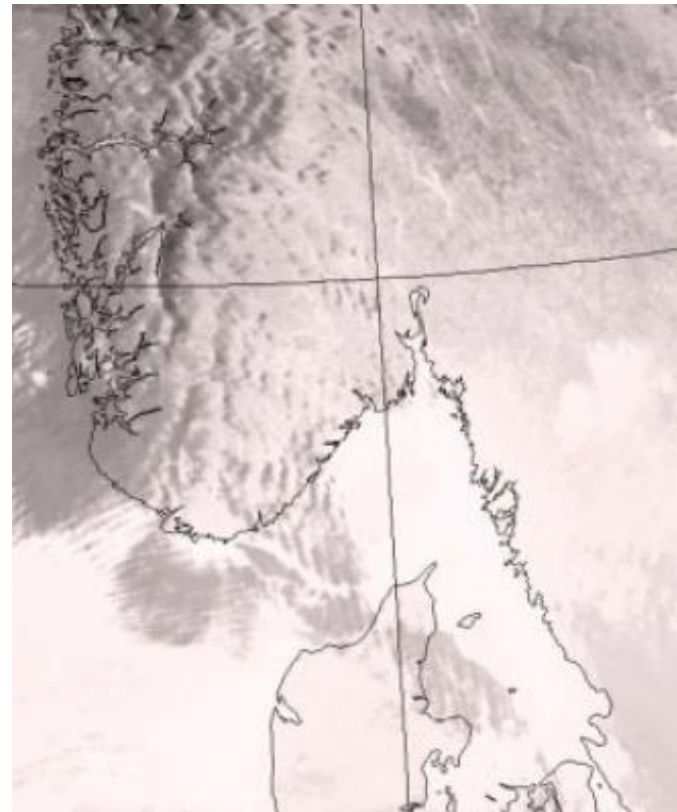
October 27, 2016 at 17:50 UTC

Mountain gravity waves

November 6, 2006

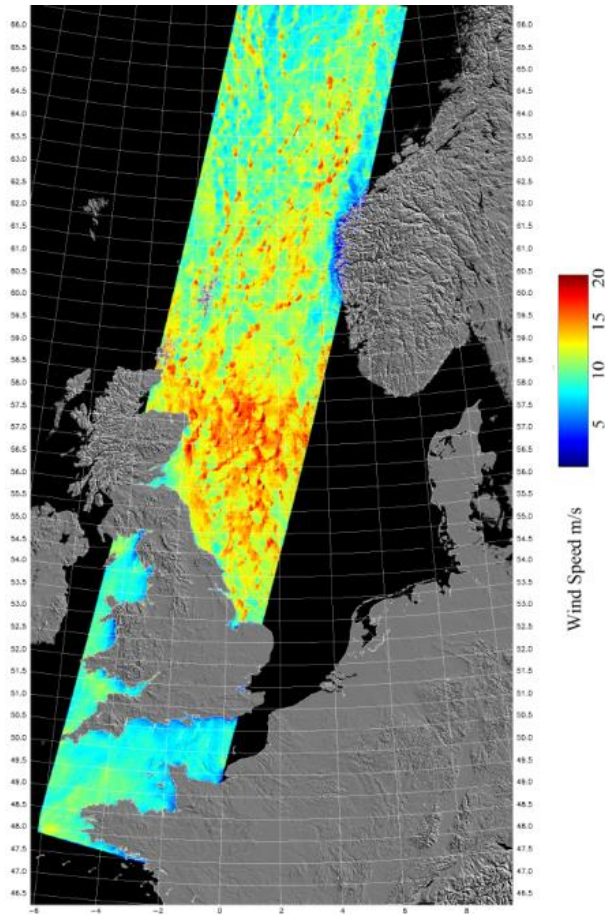


Envisat ASAR 10-m wind speed

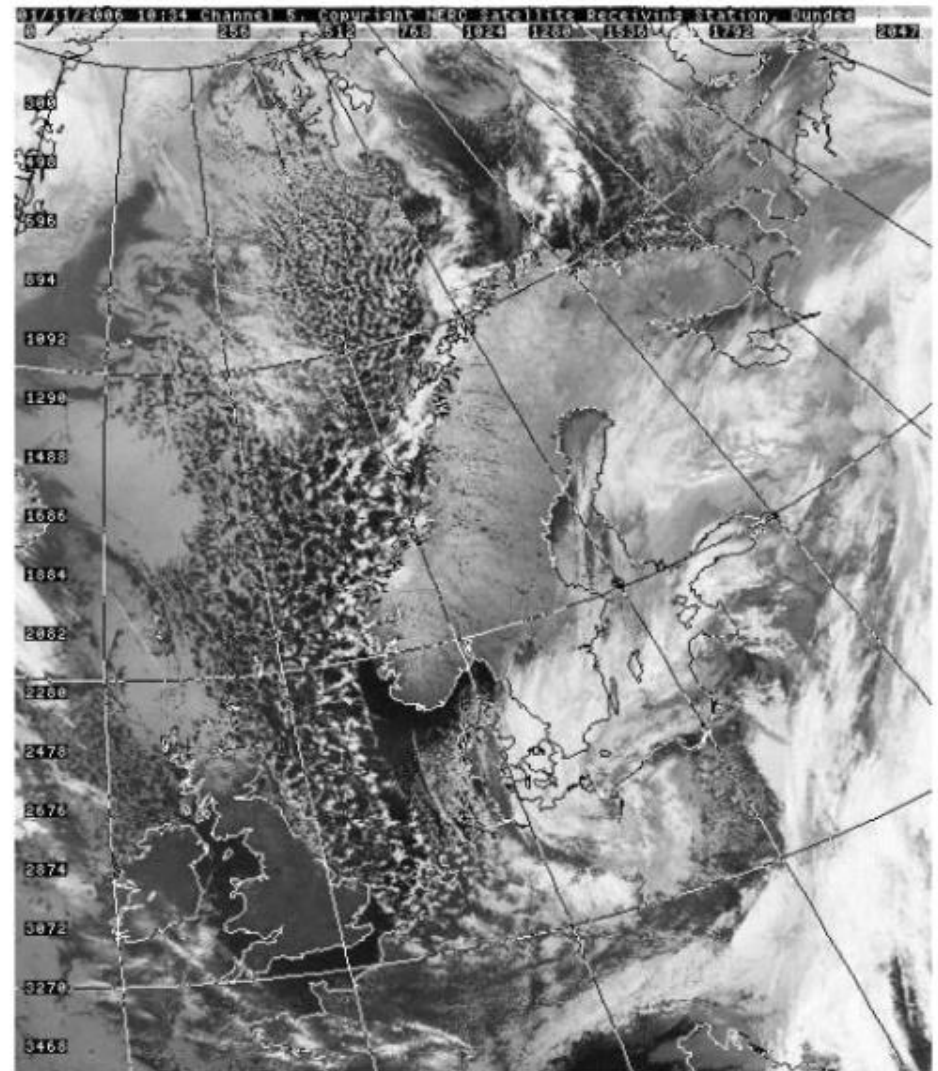


Cloud image

Open cells

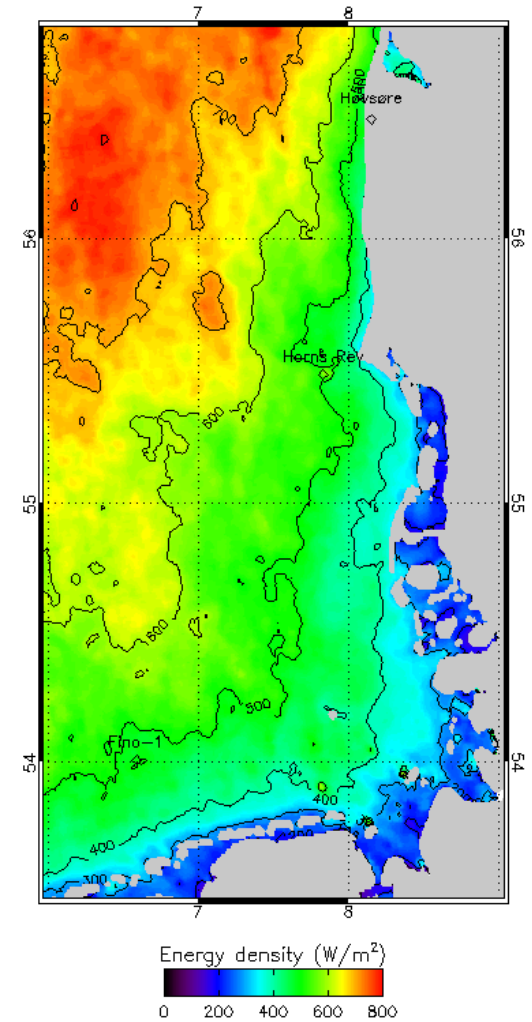
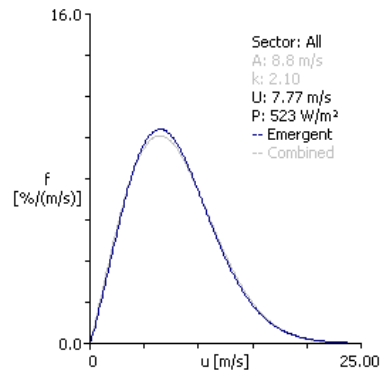
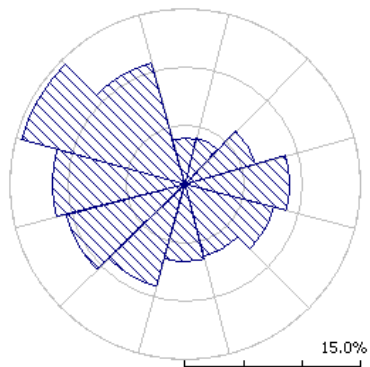
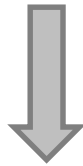
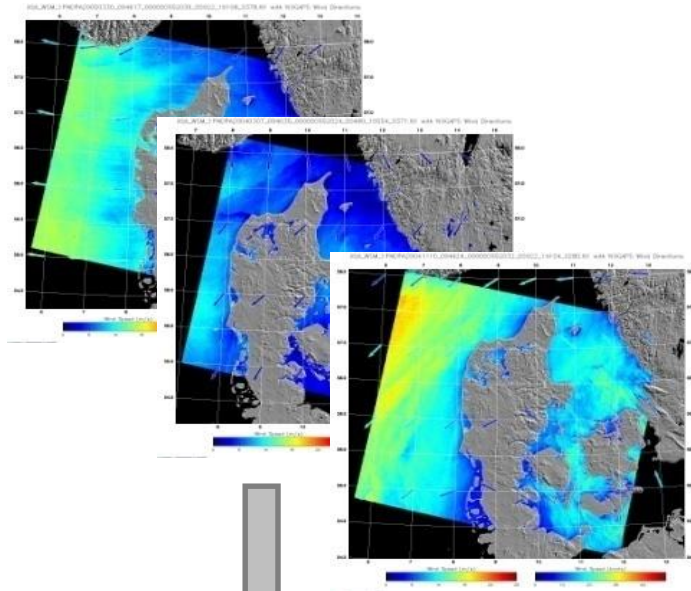


Envisat ASAR 10-m wind speed

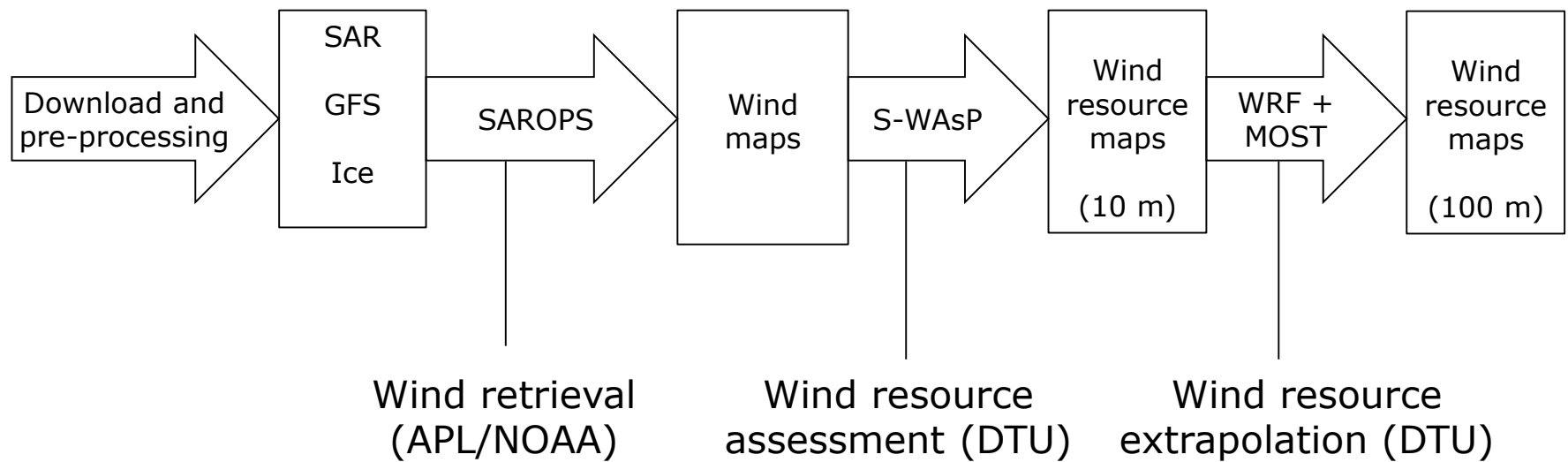


Cloud image

Wind resource mapping

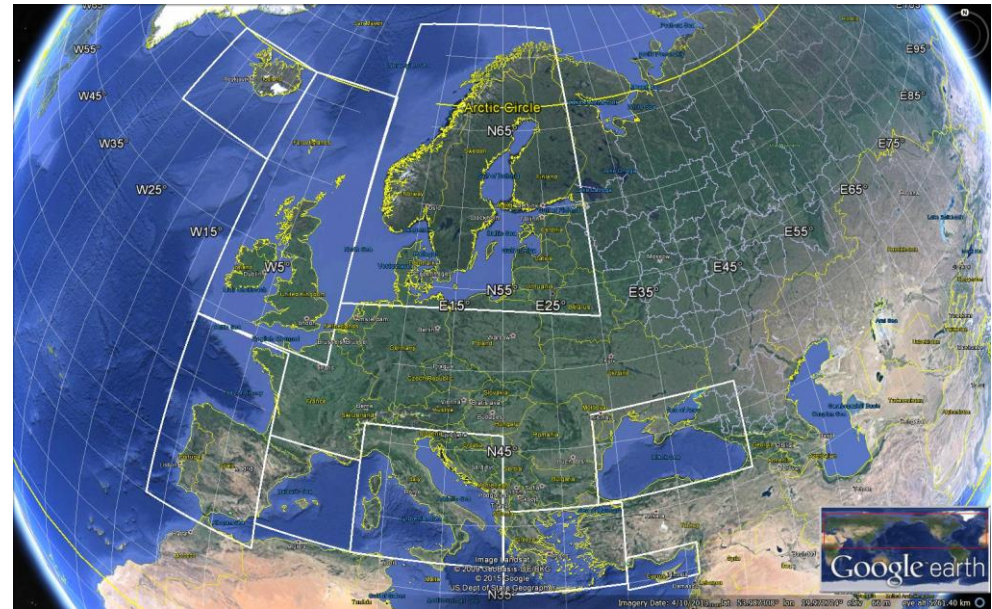


Chain of processes



The New European Wind Atlas (NEWA)

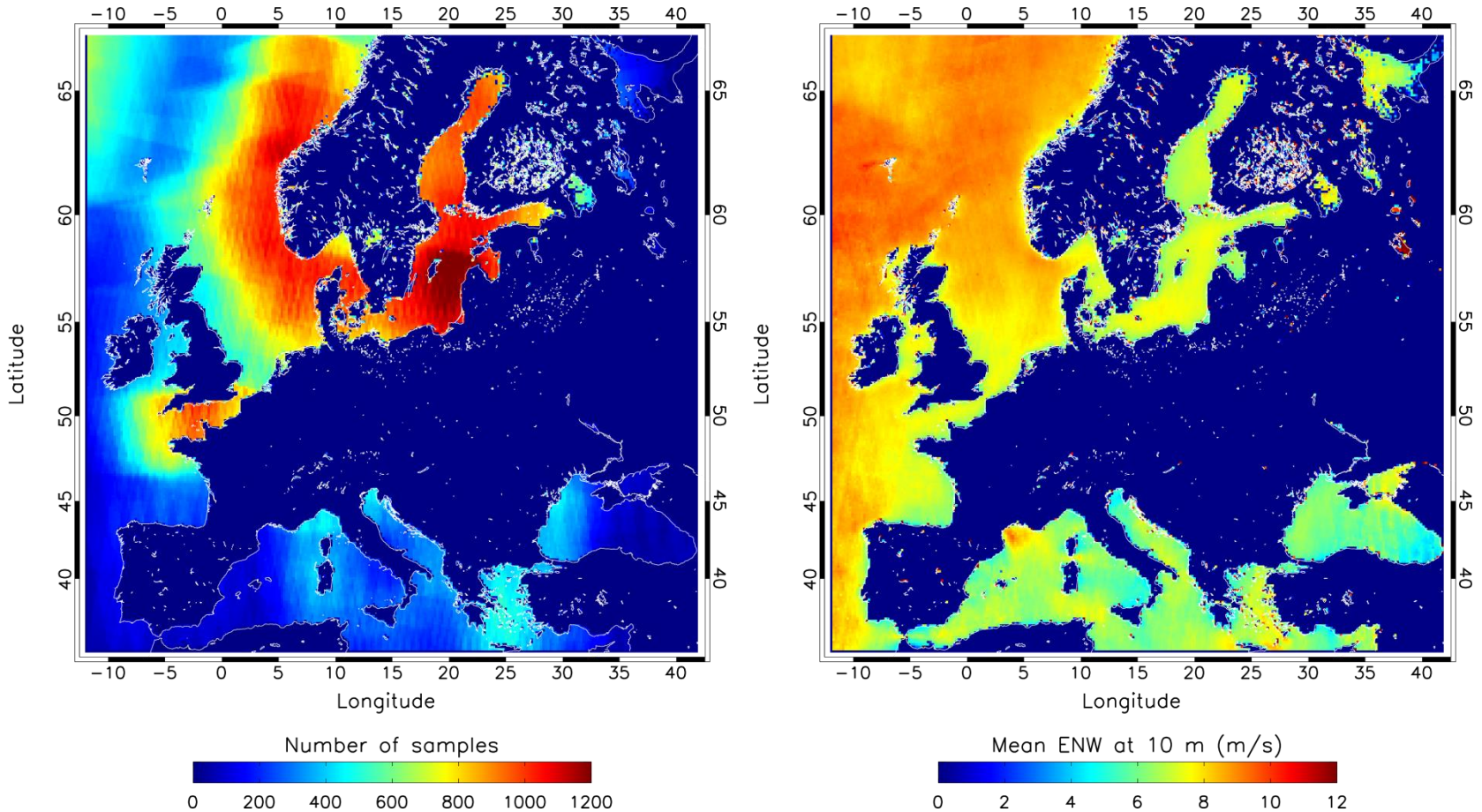
- Envisat ASAR and Sentinel-1 A/B
- Extrapolation to different heights up to 100 m
- Extensive measurement campaigns and modeling



Coverage of the satellite based atlas in NEWA

(image courtesy Google Earth)

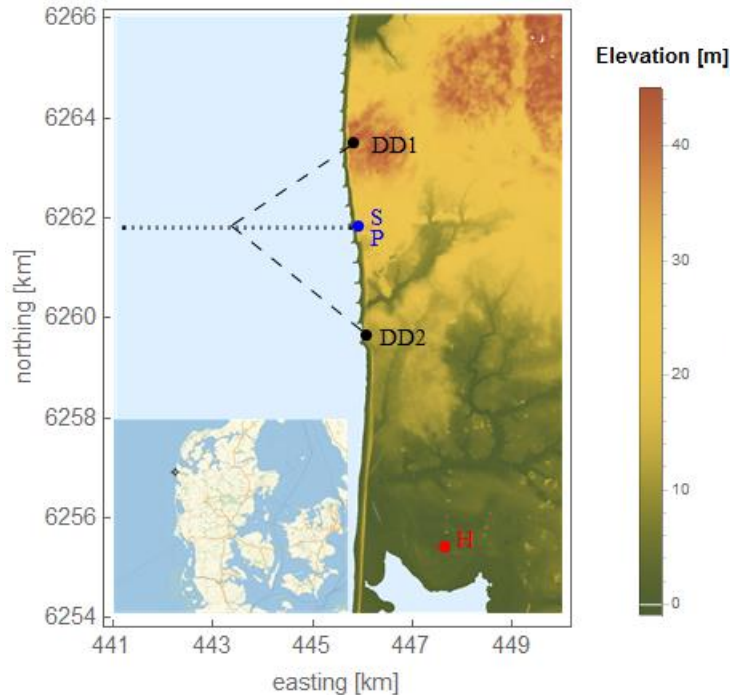
Preliminary 10-m atlas for Europe



Envisat ASAR and Sentinel-1A/B combined

SAR for coastal applications (RUNE)

- DD) Scanning lidars for dual Doppler scan
- S) Scanning lidar for PPI scans
- P) Profiling lidar,
- H) Høvsøre met mast
- Dotted line) Transect for lidar and SAR measurements



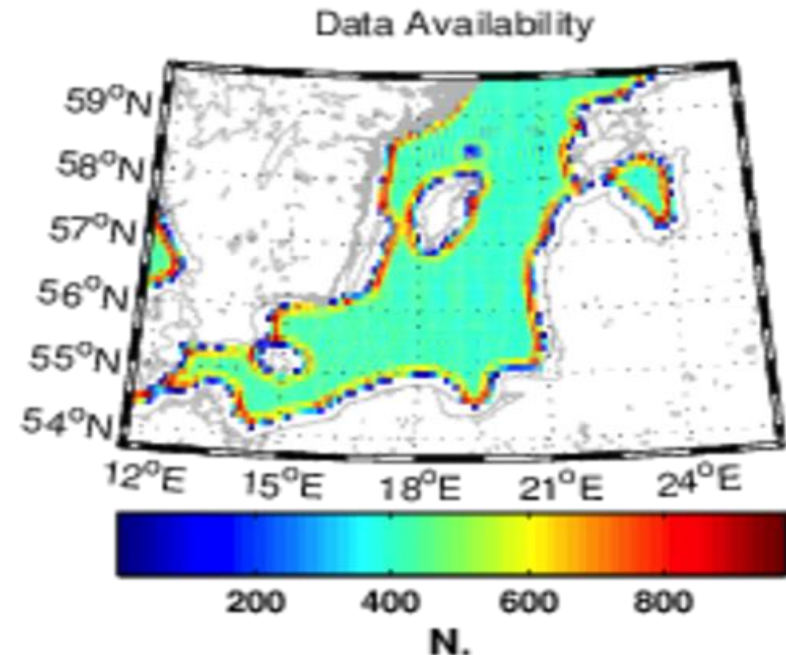
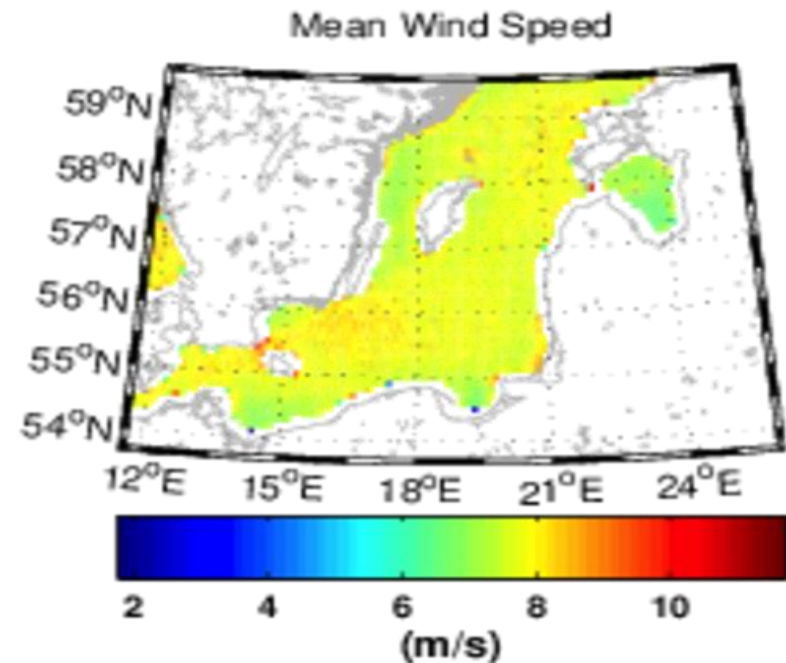
Scatterometer: ASCAT

ASCAT data analysis



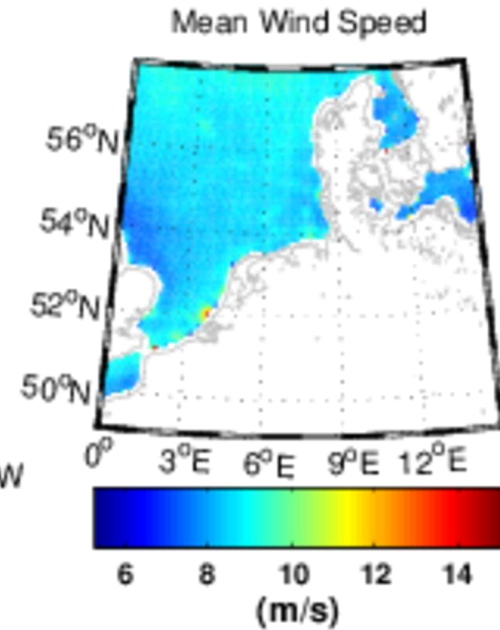
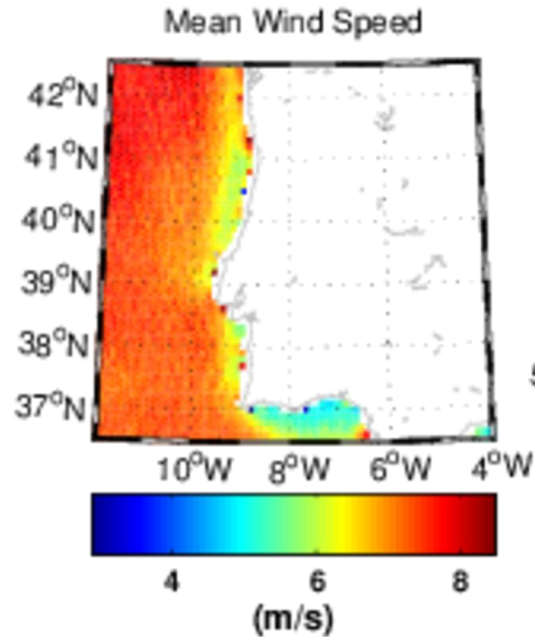
ASCAT Winds

- ASCAT 12.5 coastal product (swath)
- 2015 data
- Wind speed and direction statistics

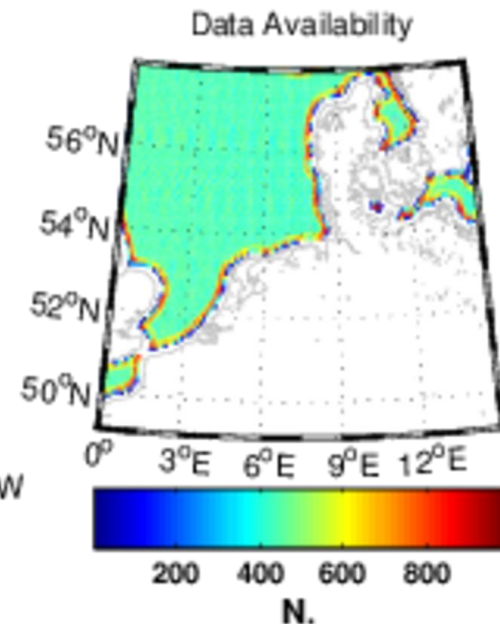
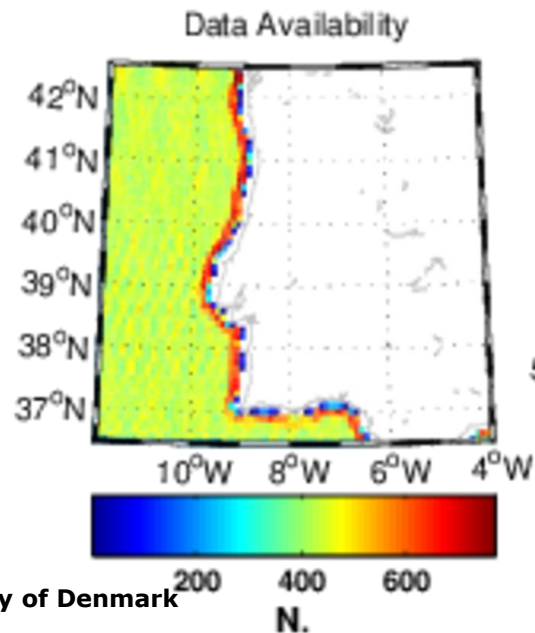


ASCAT

Mean wind speed at 10m



Data availability



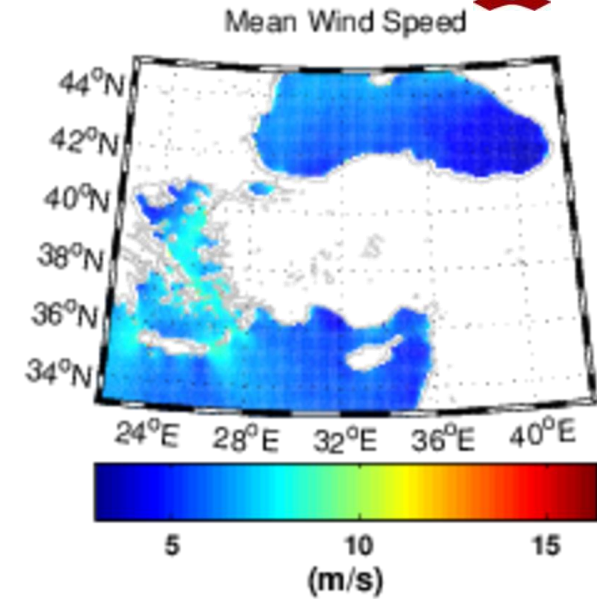
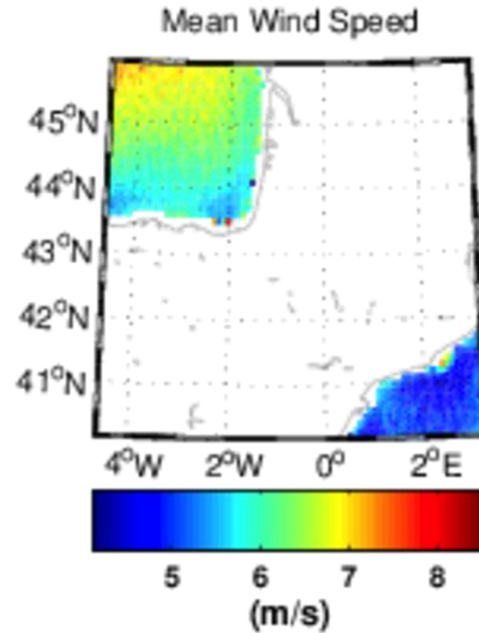
Domains: SouthEast

SouthWest

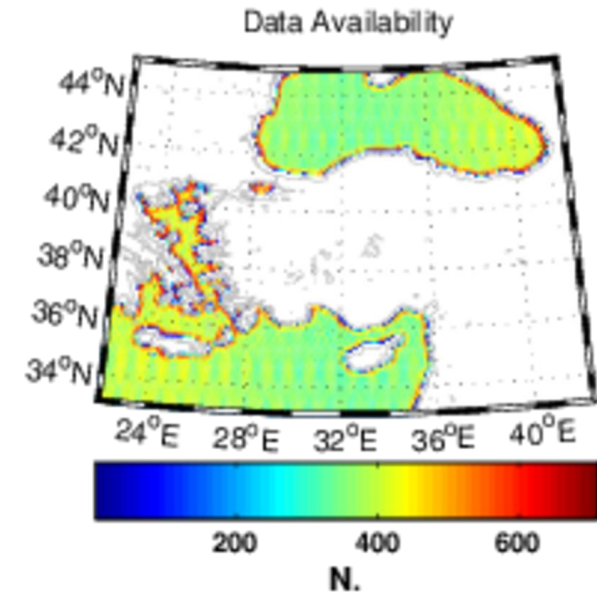
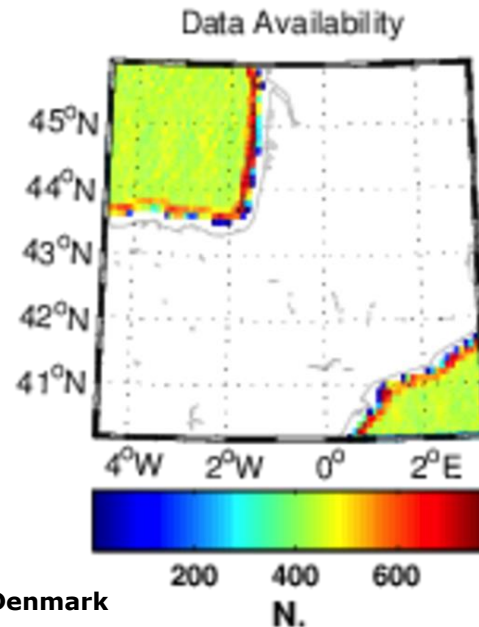


ASCAT

Mean wind speed at 10m



Data availability



Passive microwave: SSM/I

SSM/I data analysis



SSM/I and WRF key information

Wind speed analysis based on SSM/I version 7 data from satellites F8, F10, F11, F13, F14, F15, F16, and F17.

The SSM/I point data are each an average of the values of the four surrounding 0.25×0.25 degree pixels.

WRF from DTU Wind Energy calculations with 10 km grid spacing and output at 1 hour time resolution. WRF data are those from the nearest WRF grid point. This WRF run is not part of NEWA but a preliminary run done for another purpose: WRF: Andrea Hahmann and Patrick Volker.

All for the time interval 1st January 1988 to 31st December 2015. This means 28 full years.

All data are for 10 m above ground.

Poul Astrup has compared SSM/I and WRF.

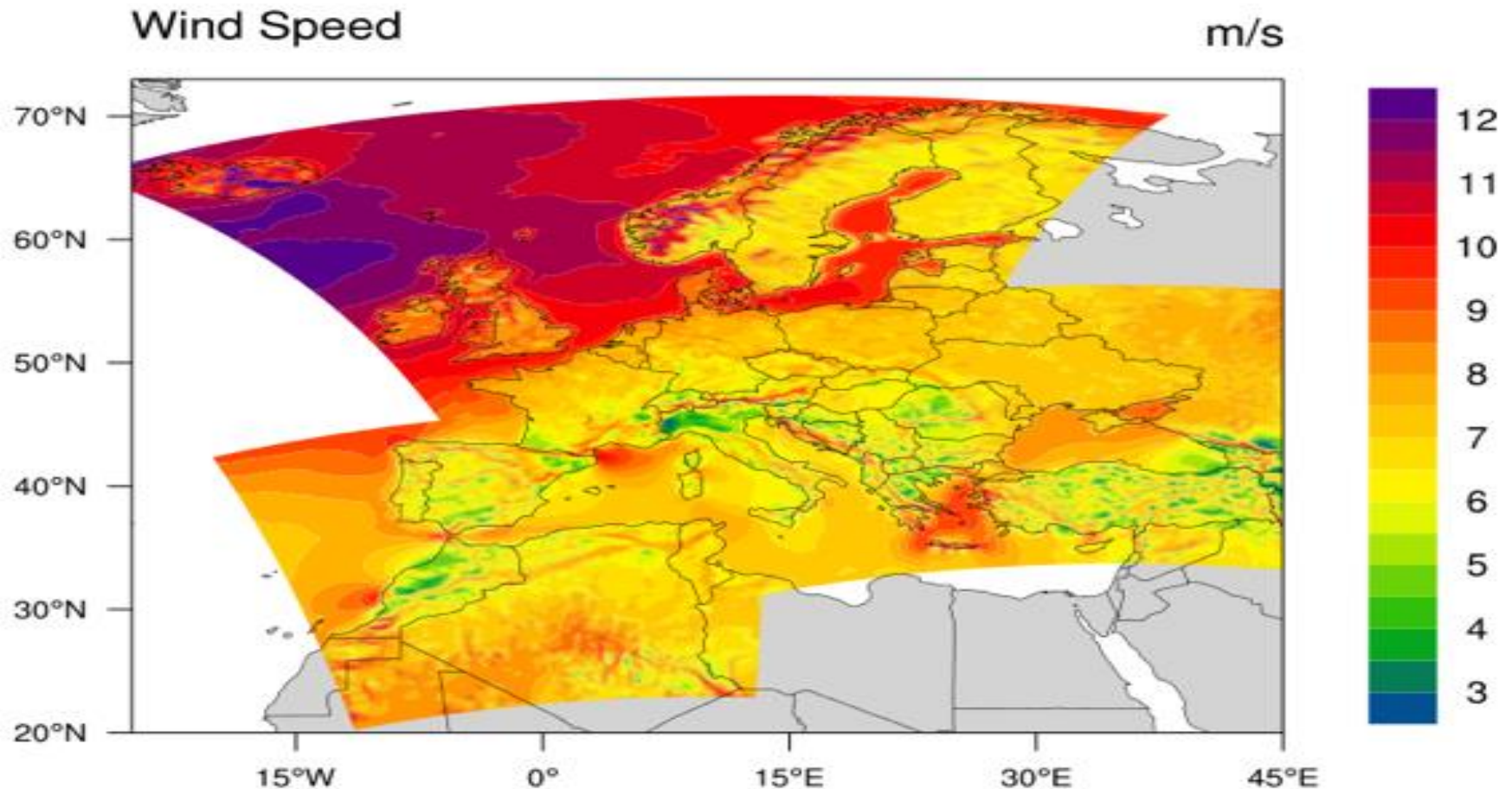
Accuracy of the SSM/I

The accuracy of the SSM/I series is now of a quality feasible for wind climate studies, i.e., changes in wind speed within 1% per decade can be assessed.

Hasager *et al.* 2016 Remote Sens. 8, 769;
doi:10.3390/rs8090769

WRF preliminary run for Europe

Wind speeds at 100 m, average 1982 to 2015

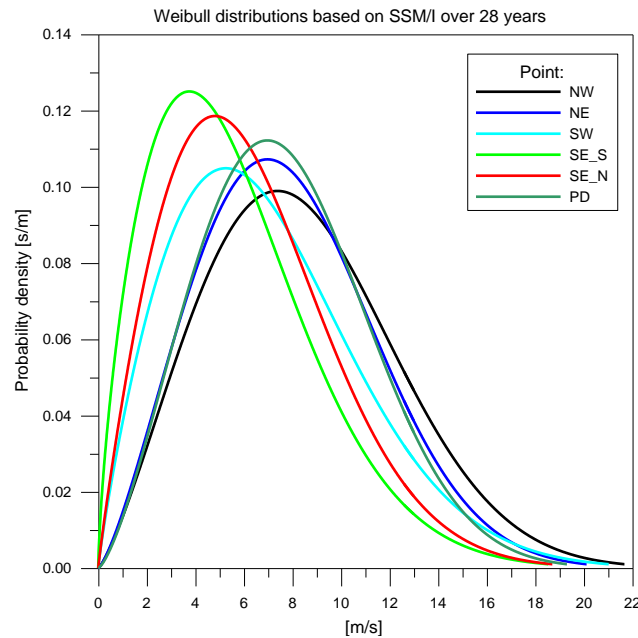


Comparison SSM/I and WRF stats

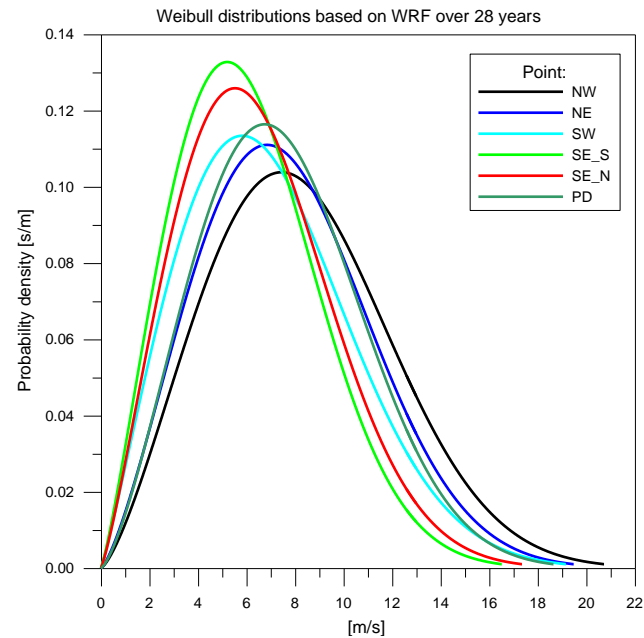
Table. Point coordinates and 28 year average of SSM/I and WRF wind speed data

Point name	Coordinates [deg]	Data count		Wind speed average		Weibull parameters			
		SSM/I	WRF	SSM/I	WRF	SSM/I		WRF	
-----	-----	-----	-----	-- [m/s] ---	[m/s] ---	--k-----	A-----	--k-----	A-----
NW:	5E 56N	51556	245424	8.33	8.28	2.28	9.51	2.38	9.36
NE:	19E 56N	52116	245424	7.68	7.62	2.32	8.89	2.35	8.67
SW:	4W 45N	43059	245424	7.01	6.94	1.88	7.87	2.12	7.87
SE_S:	30E 35N	38136	244680	5.66	5.98	1.71	6.27	2.19	6.88
SE_N:	30E 43N	41372	244680	6.23	6.35	1.92	7.05	2.20	7.28
PD:	11W 41N	40295	245424	7.62	7.41	2.40	8.72	2.41	8.43

SSM/I and WRF Weibull distributions

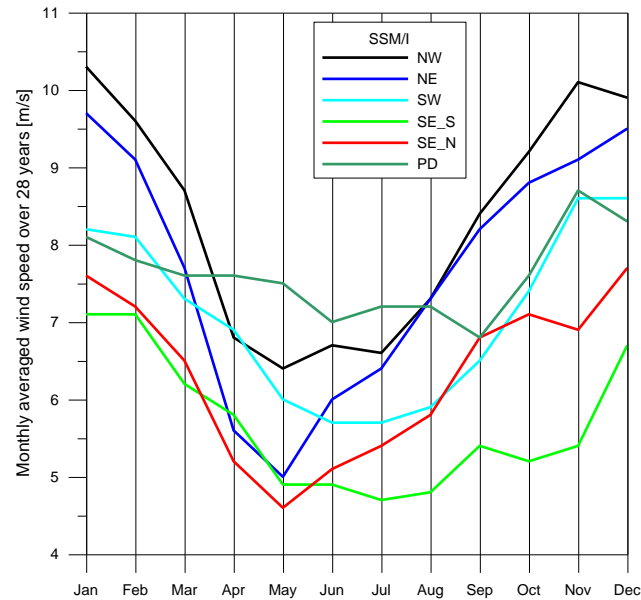


SSM/I

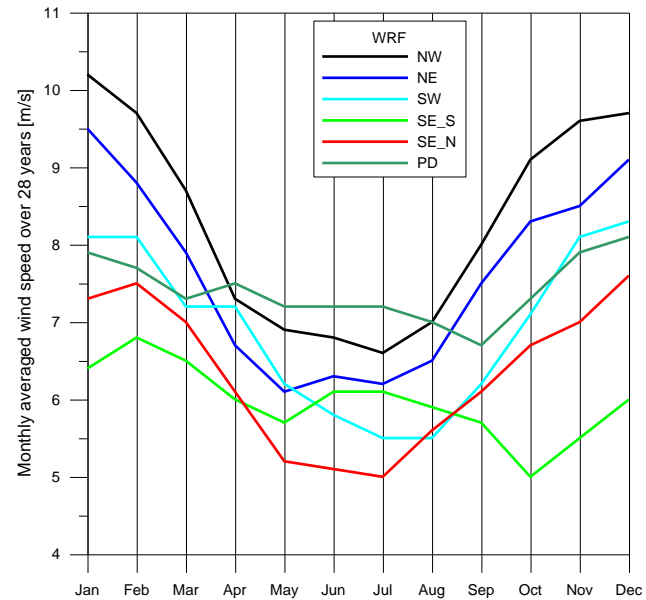


WRF

SSM/I and WRF annual averages

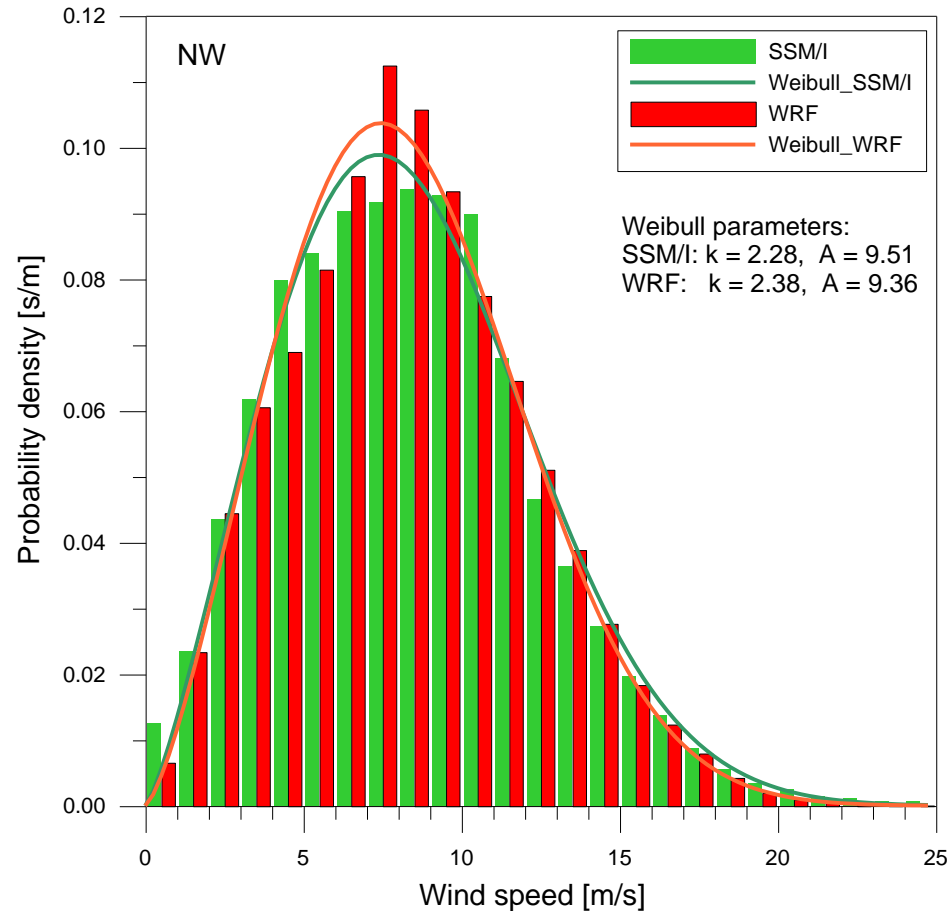


SSM/I

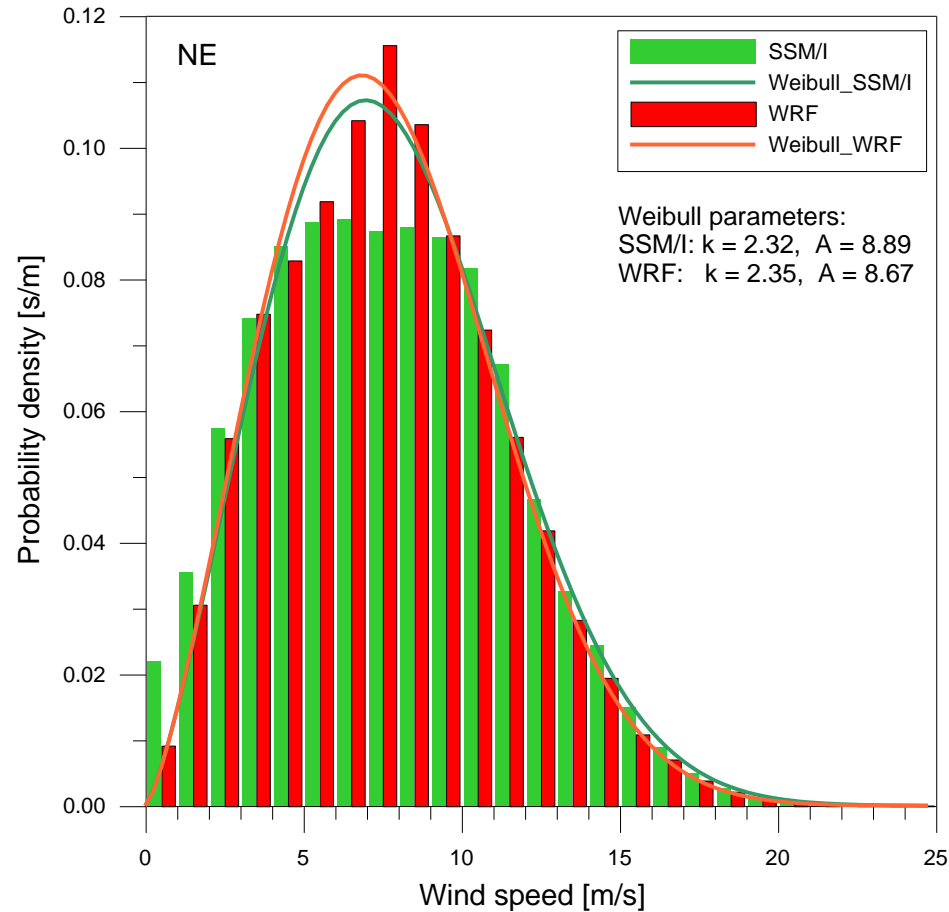


WRF

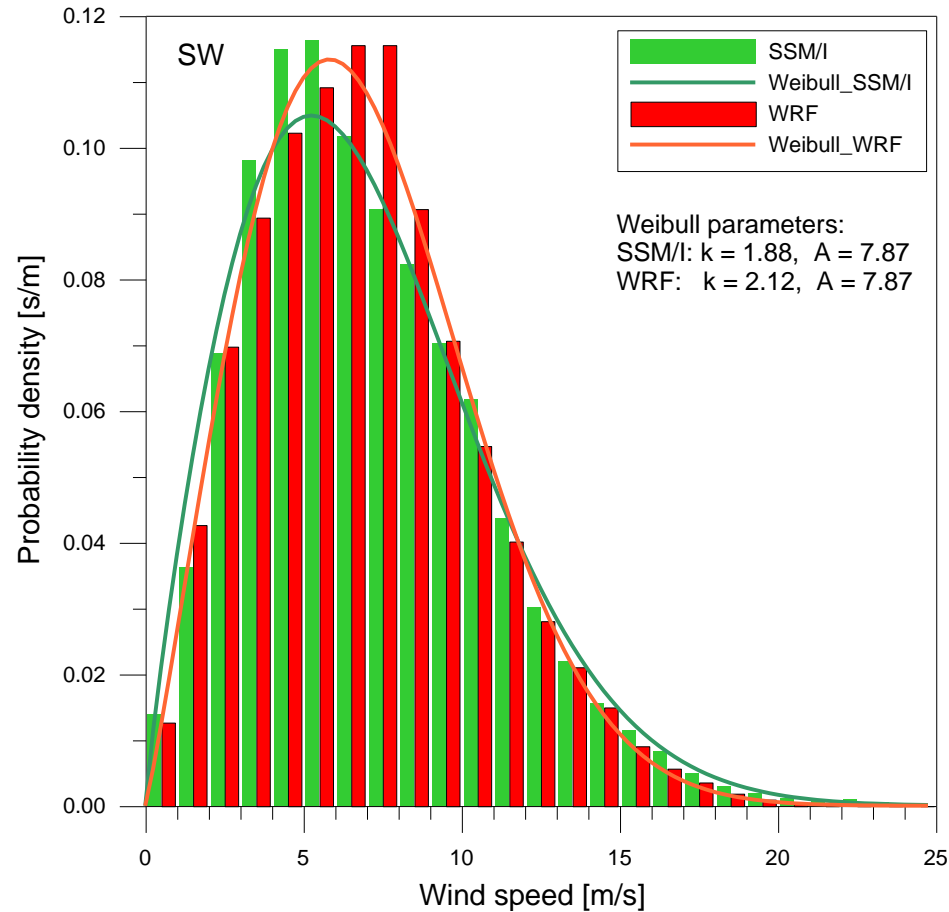
SSM/I and WRF (North Sea)



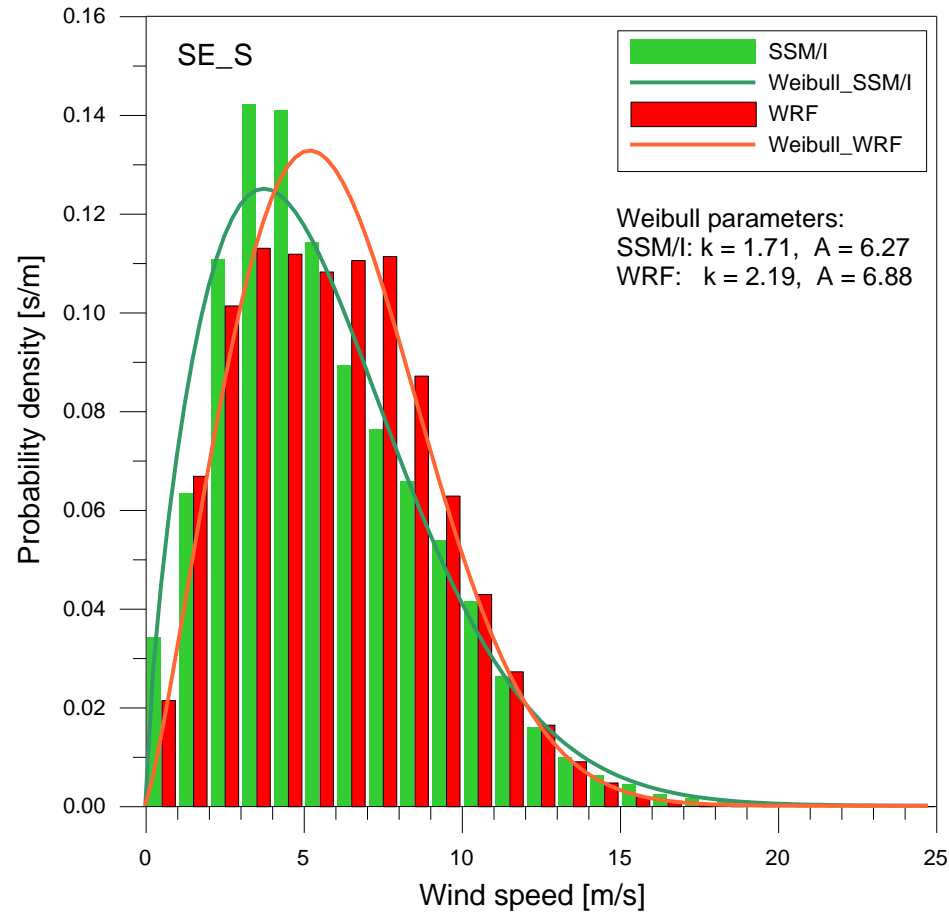
SSM/I and WRF (Baltic Sea)



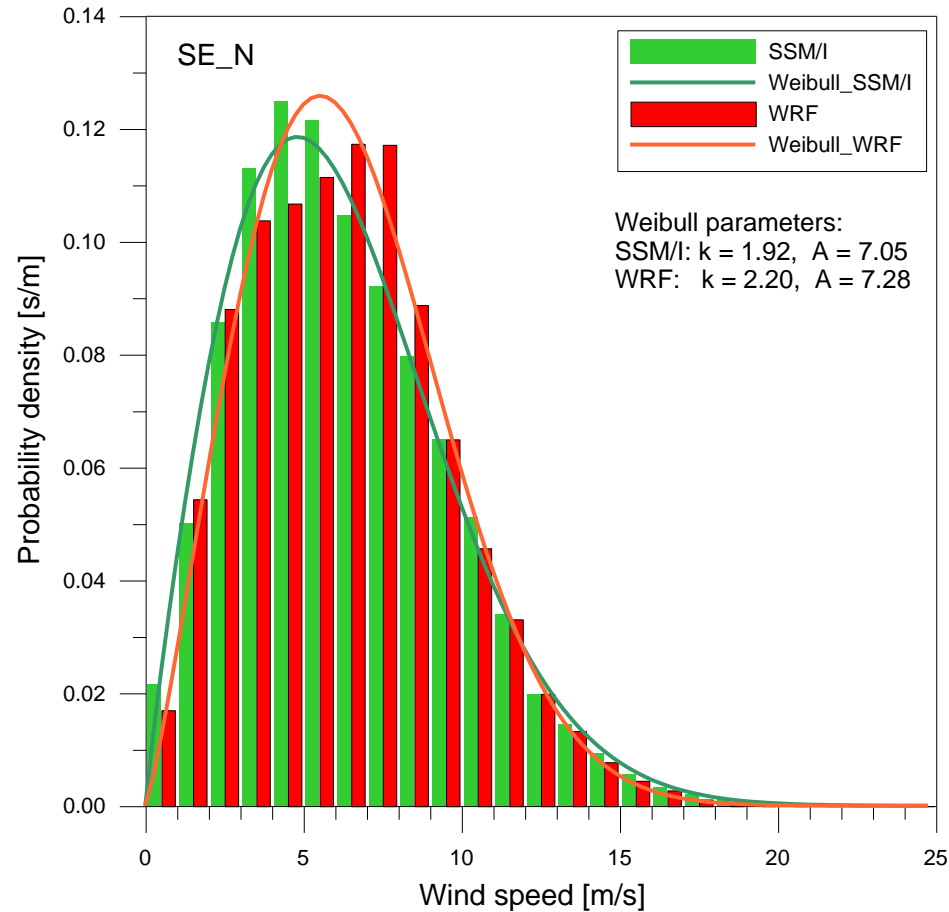
SSM/I and WRF (Atlantic Sea/Biscay)



SSM/I and WRF (Mediterranean Sea)



SSM/I and WRF (Black Sea)



Conclusions

- SAR provides **wind speed at** high spatial resolution (1 km by 1 km)
- ASCAT provides wind speed and wind direction (12.5 km by 12.5 km)
- SSM/I provides **wind speed at high frequency** during > 29 years (25 km by 25 km)

- Ocean wind retrievals offshore are valuable for:
 - 1) Model validation
 - 2) Offshore wind resource mapping
 - 3) SAR provides sufficient spatial resolution for the offshore wind atlas

- Limitations of satellite winds:
 - Lack of information above the 10-m level above m.s.l.

- Lifting of winds to higher levels is necessary (Badger *et al.* 2016)

Acknowledgements

Satellite data:

The European Space Agency (ESA), OSI SAF KNMI, Remote Sensing Systems

SAR wind retrieval systems:

JHU/APL and NOAA

Funding:

EU-NORSEWInD, Icewind, RUNE, X-WiWa, New European Wind Atlas

Collaboration:

Frank Monaldo & Christopher Jackson, NOAA

ForskEL for funding the RUNE experiment and DTU's technical staff for the execution